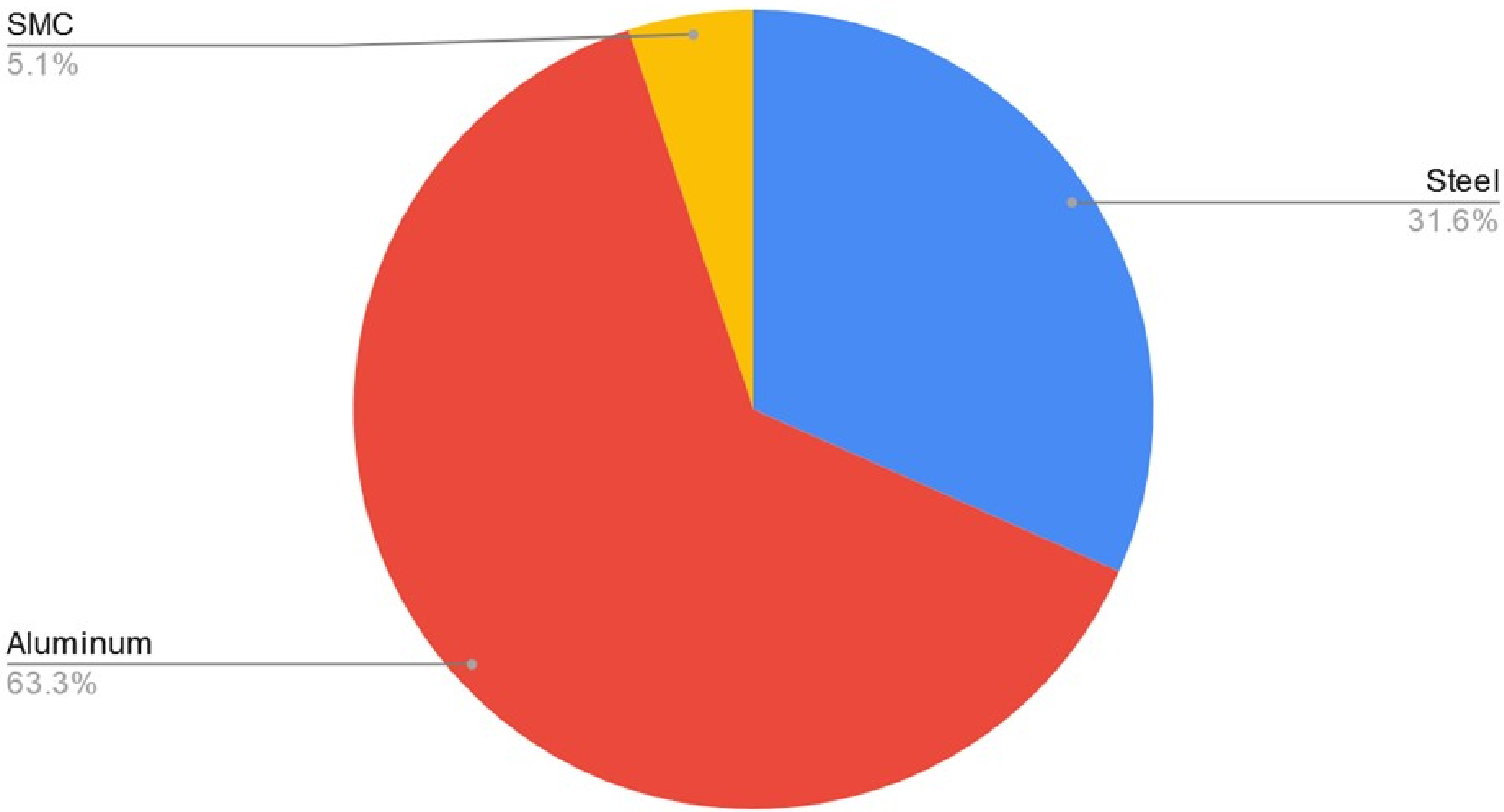
ALPHA MOTORS LTD.

Integrating Life-Cycle Environmental Concerns into Product Design

Count of What should Barns' final recommendation be?



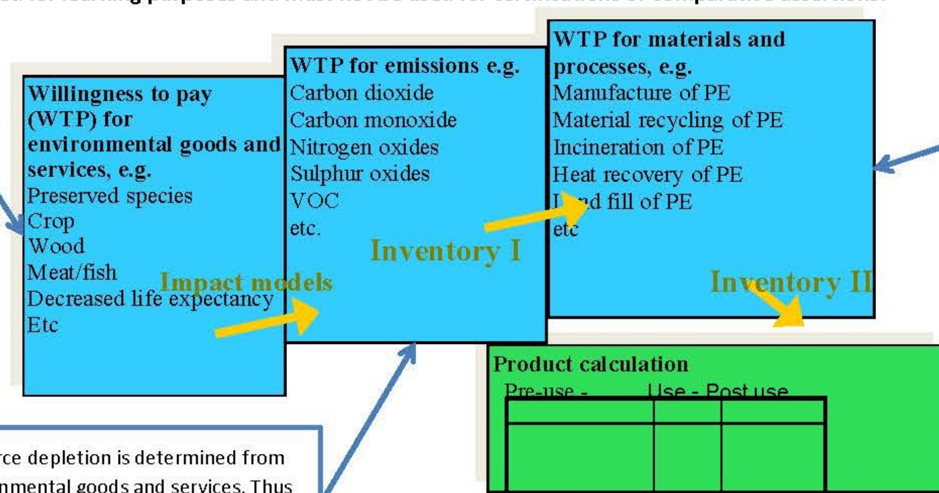
EPS - Environmental Priority Strategies in Product Design

EPS is a tool for calculation of a product's environmental damage cost during its life cycle.

The calculation is made by means of a price list on the environmental damage costs for different materials and processes. The price list is developed as shown in 1-3 below.

NB: **The data in the price lists are aimed for learning purposes and must not be used for certifications or comparative assertions.**

1. A number of environmental goods and services, used to satisfy basic human needs, are identified and valued in monetary terms. Current OECD inhabitants willingness to pay (WTP) for marginal changes in these goods and services are assessed. The values are expressed in ELU (Environmental Load



3. The WTP for avoiding environmental impacts by different materials and processes is detrmined from how much of different emissions and resource depletions they cause. Such WTP data may be found under worksheets "Polymers", "Metals" etc.

2. The WTP for decreased emissions and resource depletion is determined from how much they change the availability of environmental goods and services. Thus each unit of emissions and resource depletion gets a specific value. These calculations are described in a SLC report 2015:4a, 4b and 5, which can be

4. An EPS calculation is made in a similar way as an ordinary cost calculation for a product's life cycle. Environmental damage costs are then copied from the worksheets "Polymers" etc and pasted to the Product calculation worksheet. An example of this is shown at the

EPS methodology

- Swedish methodology
- Environmental Load Unit (ELU) = Environmental Load Index (ELI) x Product Quantity
- **ELI**s are the key indices that indicate the relative environmental impact associated with the production, use, and disposal of a particular product or material.
- EPS relates all of the physical consequences of the production, use, and disposal of a material to its impact on five environmental "safeguard subjects”
  - - biodiversity, human health, biological production, resources, and aesthetic values.
- The various weighting factors are based on the environmental objectives of the Swedish Parliament.

Relative value of unit effects

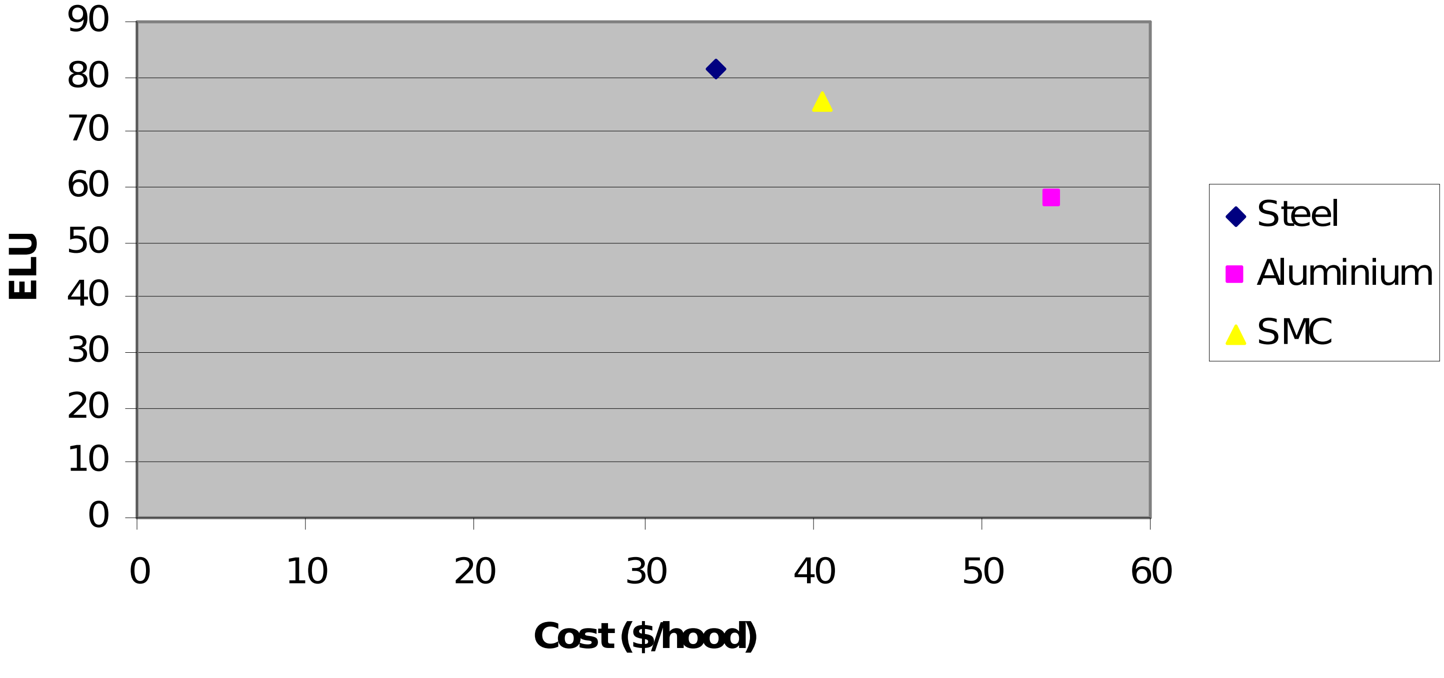
- Expressing each unit effect in terms of its economic worth and associated risk factors.
- Formally, the value of each unit effect is set equal to the product of five factors, F1 through F5.
  - F1 is a monetary measure of the total cost of avoiding the unit effect.
  - The extent of affected area (F2),
  - The frequency of unit effect in the affected area (F3),
  - and the duration of the unit effect (F4), represent "risk factors" similar to those employed in toxicological risk evaluations.
  - F5 is a normalizing factor, constructed so that the product F1*F5 is equal to the cost of avoiding the unit effect that would arise through the use or production of one kilogram of material.
- The product of all five factors yields the contribution of a particular unit effect to environmental load. Summing the value of each unit effect yields the "environmental load index" (ELI) in units of environmental load per unit of material consumed or processed (ELU/kg).

[redacted]	Nuisance	Morbity	CO_2 effect	Oxidant effects
[redacted]	Human Health	Human Health	All 5	All
[redacted]	CO Concentration	CO Concentration	CO_2 Equivalents	Ethene Equivalents
[redacted]	100	100,000	0.08887	0.0005
[redacted]	750,000,000	750,000,000	1	1
[redacted]	0.1	0.001	3	3
[redacted]	0.01	0.01	1	1
[redacted]	6×10^{-13}	6×10^{-13}	1	1
[redacted]	0.000045	0.000045	0.2666202	0.0015
[redacted]	0.268152			

- Two criteria are applied when establishing which impacts will become unit effects:
- the importance of the impact on the sustainability of the environment
- and the existence of an ability to establish a quantitative value for that impact within traditional economic grounds
- Examples of unit effects for human health include:
  - mortality due to increased frequency of cancer;
  - mortality due to increased maximum temperatures;
  - food production decreases (and, hence, increased incidence of starvation) due to global warming

	Cost	Weight	End of life	ELUS w/End of Life	ELUs with 50% recycling	ELU without End of Life
Steel	- (raw $21.93 finished $34.30)	+(hood 11.92 kg total with raw mat 16.688 kg)	100% recycling	81	87	92
Aluminum	+ (raw $31.36 finished $54.30)	- (hood 8.25 kg total with raw mat 11.55)	100% recycling	58	80	89
SMC	+ (raw $22.43 finished$ 40.56)	- (hood 9.3 kg total with raw mat 10.23)	0% recycling	75	76	73

Environmental performance vs. Production Cost



LCA Methods vs. Non LCA methods

- **LCA Methods** - Electronic systems cannot be adequately recycled. A green design project requires to weigh all environmental implications of different alternatives

Advantages

- Easy comparison – One numeric result

Disadvantages

- Requires full knowledge of all processes (production to recycling)
- Data not fully available to user
- Evaluation may include political aims/scientific impact correlations

- **Non -LCA Methods** – Evaluate product contents, not the processes. Result – a rating of potential hazards to humans or environment.

Advantages

- Complements LCA
- Similar results to LCA, with less complexity

Disadvantages

- Not complete evaluation of environmental effects

Comparison EPS vs. other methods

	Simple	Accurate/ Thorough	Affordable	Easy to Understand	Easy to calculate	When to use
EPS	✓	✓	✘	✘	✘	Needed detailed analysi
BUWAL	✓	✓	✘	✘	✘	Needed detailed analysi
Eco-Indicator 95	✓	✓	✘	✓	✘	Separation btw data suppliers and data users
Simplified LCA	✓	**1/2**	**1/2**	✓	✓	Decrease inventory Complexity
Non LCA methods	✓	✘	✓	✓	✓	Less data needed

Value of EPS in decision making

Strengths

- Analytical, non-emotional
- Comprehensive
- Results in single number
- Can be used in design phase
- Can perform sensitivity analysis

Weaknesses

- Difficult to explain to lay-people
- Cannot tell impact on specific areas of the environment
- Time consuming
- No guidance on how to integrate with factors such as cost and quality

A useful, but not great, tool

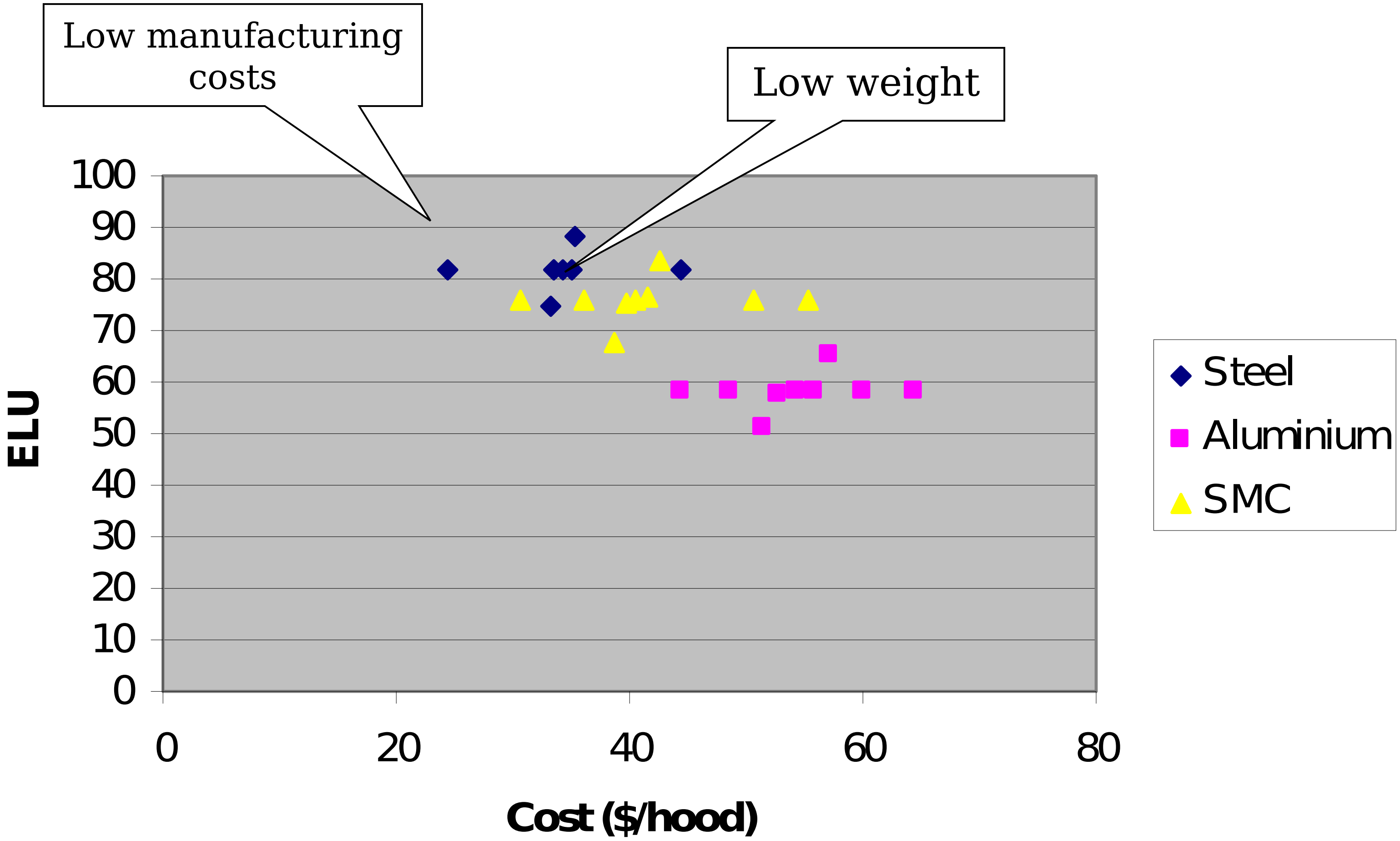
- **Helps ensure that environmental issues are heard in the design phase**
- **However, it was ultimately only of some value, with a large "cost" of using the tool**

Sensitivity Analysis

Sensitive variables

	Steel		Aluminum		SMC	
Effect of 10% change in	**ELU %**	**Cost %**	**ELU %**	**Cost %**	**ELU %**	**Cost %**
Material Used	10.0	3.6	10.0	4.2	10.0	4.5
Manufacturing Scrap	0.2	2.5	0.4	3.0	1.7	3.2
Raw Material Cost	—	3.7	—	4.2	—	4.4
Manufacturing Costs	—	6.4	—	5.8	—	5.5
Disposal Landfill	—	—	—	—	—	—
Disposal Incineration	—	—	—	—	—	—
Disposal Recycling	—	—	—	—	—	—
Recovery Transportation	—	—	—	—	—	—
Recovery Disassembly	—	—	—	0.1	—	0.1
Manu. Scrap Landfill	-0.5	-0.3	—	-0.1	0.1	—
End of Life Landfill	-1.3	-0.3	-5.4	—	0.7	—

Different Scenarios: variation in assumptions



Future ways to use LCA in the company

Worth using a tool

- Ensures environmental concerns are heard
- Scientific and analytical, not emotional

Desired characteristics of a tool

- Analytical
- Simple, easy-to-use
- Understandable
- Accurate/thorough
- Affordable

Use a Simplified LCA tool

Appendix: Assumptions

Material Used	Major Factors			
	Material Used (kg)	Manufacturing Scrap	Raw Material Cost ($/kg)	Manufacturing Costs ($/hood)
Steel				
Low Range	10.92	30%	$0.70	$11.93
Realistic/Middle Range	11.92	40%	$0.75	$21.93
High Range	12.92	50%	$0.80	$31.93
Aluminum				
Low Range	7.25	30%	$1.50	$21.36
Realistic/Middle Range	8.25	40%	$2.00	$31.36
High Range	9.25	50%	$2.50	$41.36
SMC				
Low Range	8.3	5%	$1.32	$12.43
Realistic/Middle Range	9.3	10%	$1.76	$22.43
High Range	10.3	15%	$3.20	$32.43

Comparison EPS vs. other methods

	Advantages	Disadvantages
EPS	**Simplified result - environmental indices of material and processes** **Defines safeguard subjects (resources, biodiversity)**	**Not transparent factors (based on local policies or a social value system)**
BUWAL	**Defines maximum allowed emission per area without critical flows**	**Determination of critical/actual flows for all emissions can be complicated and it depends on national data**
Eco-Indicator 95	**Calculates 1 value/material = weighted sum of ecological impacts** **Simplifies process inventory handling through modular data sources** **Combines simplification (1 number) with possibility of separation btw data suppliers and data users**	**The designer may not know specifics of evaluated processes. If a material is not in database, it has to be investigated with same method by original database supplier.**
Simplified LCA	**Reduces assessment complexity via reducing scope of data –**	**A complete process chain has to be investigated, even if only**